

BIOASSESSMENT OF PRAIRIE POTHOLE WETLANDS FOR IMPACTS FROM INSECTICIDES AND HERBICIDES



by
Mary G. Henry, Michael W. Tome¹, Charles H. Welling,
and Samuel Miller

Minnesota Cooperative Fish and Wildlife Research Unit
University of Minnesota
St. Paul, MN 55108

¹North American Waterfowl Management Plan
U.S. Fish and Wildlife Service
Washington, D.C. 20240

December 1992



Bioassessment of Prairie Pothole Wetlands for Impacts from Insecticides and Herbicides

Draft Final Report

Submitted to:

Lynn Lewis
Fish and Wildlife Enhancement
U.S. Fish and Wildlife Service
St. Paul, MN 55101

and

Peter Albers
Patuxent Wildlife Research Center
Fish and Wildlife Service
Laurel MD 20708

By:

Mary G. Henry, Michael W. Tome¹, Charles H. Welling, and Samuel Miller

Minnesota Cooperative Fish and Wildlife Research Unit
University of Minnesota
St. Paul MN 55108

¹North American Waterfowl Management Plan
U.S. Fish and Wildlife Service
Washington D.C. 20240

1 December 1992

Project # 90-3-101

ACKNOWLEDGMENTS

This research was supported under Cooperative Agreement No. 14-16-0009-1566 with USFWS: Fish and Wildlife Enhancement Office, St. Paul, MN and the Environmental Contaminants Section, Patuxent Wildlife Research Center, Laurel, MD. In addition to this support, we are grateful for assistance with site selection and support during the field season received from the staffs of the Morris District, Minnesota Waterfowl and Wetlands Management Complex (MWWMC), USFWS. We also are grateful to Roland Sigurdson who provided assistance in the field under trying conditions. Chemical analyses of spray cards and water samples were done by Dr. Joel Coats and Mr. Jim Sink, Iowa State University, Ames, IA.

INTRODUCTION

The Minnesota Cooperative Fish and Wildlife Research Unit (MCFWRU) became involved in research on the impacts of pesticides on wetland wildlife in 1990. This research is a continuation of work done in North Dakota during the late 1980's by the Patuxent Wildlife Research Center, U.S. Fish and Wildlife Service (USFWS).

In this report we describe a field experiment conducted during 1990. This research was designed to evaluate the impact of the pesticide esfenvalerate on invertebrates after entering wetlands in the form of drift from aerial application to adjacent crop land.

BACKGROUND

Broad-spectrum insecticides have been sprayed in Minnesota on non-cropped wetlands and uplands, e.g. roadsides and Crop Reserve Program land, to control grasshopper outbreaks and as part of routine agricultural practice. These wetlands and uplands are critical habitats for many migratory waterfowl, songbirds and upland game bird species. In recent studies done in North Dakota there has been documentation of direct mortality occurring in both waterfowl ducklings and the aquatic invertebrate communities upon which they feed due to the aerial application of ethyl parathion (Grue et al. 1989). Information is needed to determine how the growth and survival of ducklings that survive insecticide application are affected when their prey base is depleted by such spray events. Increasing our understanding of the effects of agricultural insecticides on the quality of prairie wetlands will assist wetland managers, farmers, and agricultural extension personnel in providing high quality prairie wetland habitat for wildlife while continuing to meet the needs of agriculture.

STUDY SITE SELECTION AND EXPERIMENTAL DESIGN

This research was conducted on a series of seasonally or semi-permanently flooded, emergent wetlands (Cowardin et al. 1979), also known as Type 3 or 4 wetlands (Shaw and Fredine 1956), of one hectare or less in size, located on private land in the vicinity of Morris, MN. Five wetlands were randomly assigned to each of two treatments: adjacent to lands to be sprayed with esfenvalerate, i.e. treated sites, and adjacent to lands not to be sprayed with esfenvalerate, i.e. reference sites. For development of further reference information, invertebrates were also sampled in five wetlands located on Waterfowl Production Areas, MWWMC, also in the vicinity of Morris.

METHODS

Insecticide Application and Deposition

Esfenvalerate, Asana XL^R, was aerially applied at the rate of 34 g ha⁻¹, the maximum label application rate for grasshoppers on non-crop land (Anonymous 1991). The insecticide was mixed with water and applied at the rate of 24 l of solution ha⁻¹ at 24 lbs pressure per sq in through a boom equipped with 51 TeeJet^R D-7 Disc-Core Type full cone spray tips 7 in apart.

Insecticide deposition was measured with spray cards which were 7.5 cm diameter pesticide grade filter papers. Three spray cards were placed on separate stakes at each invertebrate sampling station in each wetland adjacent to cropland to which esfenvalerate was applied. In addition, a transect was established with one end located in the native vegetation adjacent to the wetlands 5 m in from the edge of the cropland and the other end extending 40 m out into the cropland. The transect was perpendicular to the border between the cropland and wetland. Spray cards were placed at ten stations and were located at 5 m intervals along the transect.

The extent of upland and emergent vegetation surrounding the open water areas of each wetland was mapped to provide an estimate of the buffer between the treated fields and the open water areas.

Invertebrates

Three sampling stations were located in each wetland along transects from the center to the periphery of the wetland. The three transects were separated from each other by 120°. Each station was located in the open water zone 2-3 m out from the edge of the emergent vegetation.

The response of wetland invertebrates to esfenvalerate application was evaluated by taking sweep net samples and benthic cores. Samples were collected one day before application of the insecticide, one day after application, and at weekly intervals during the four weeks following application. Results from collections made one day before and one day after spray are presented in this report.

Sweeps were made with a net with an opening 46 x 20 cm pulled through the water column approximately 0.7 m below the surface for a distance of 1 m.

At each of the three invertebrate sampling stations in each wetland, four cores 5 cm in diameter were collected and pooled in a single container with 10% formalin. Twenty five of the 39 samples collected before application of the treatment were completely sorted. The remaining 14 samples collected before treatment as well as 25 of the 26 samples collected after treatment were subsampled (Waters 1969). Benthic material to be sorted was mixed with sugar to float the invertebrates and separate them from the detritus present (Lackey and May 1971).

RESULTS AND DISCUSSION

In the 15 samples for which all 8 subsamples were sorted, the distribution of total organisms among subsamples was random in 13 cases and contagious in 2 (Elliot 1971). Elliot (1971) recommended that at least 5 subsamples from each sample be examined to determine whether the distribution of organisms among subsamples is random and justifies subsampling. Keeping this recommendation in mind, the distribution of chironomid larvae in samples from which only three subsamples were taken was examined since chironomids were the most commonly encountered organisms in this study and they are important food for waterfowl. In the 36 samples which contained chironomid larvae, the distribution of chironomids among the three subsamples was random in 34 cases and contagious in two. These results indicate that subsampling of benthic samples collected during this study is an acceptable alternative to sorting of whole samples.

Prior to the application of esfenvalerate, there were no differences in abundance of invertebrates among treatments (Table 1). Little insecticide drifted from treated fields into the experimental wetlands (Figure 1). In four of the five wetlands adjacent to treated croplands, esfenvalerate was detected on spray cards at one of the three sampling stations in each wetland. At only one of these four sampling stations was the rate of deposition greater than 0.3 g ha^{-1} . Esfenvalerate was not detected in water samples collected from wetlands in either the treated or reference groups. The absence of a reduction in invertebrate density in experimental wetlands after application of esfenvalerate to adjacent cropland (Table 1) is consistent with the apparent lack of drift of esfenvalerate into wetlands adjacent to treated fields.

The distance from the border between the treated fields and uplands to the border between the emergent vegetation and open water of the adjacent wetland was 50 m on average. This distance, which can be considered a buffer between the treated fields and wetland sampling stations, is slightly less than the 65 m recommended by Frank et al. (1991) and much less than the 250 m recommended by Ernst et al. (1991). Future examination of buffer strip interactions with drift of pesticides into wetlands under variable wind speeds is warranted

LITERATURE CITED

Anonymous. 1991. Crop protection Chemicals Reference, Seventh edition. John Wiley and Sons, New York, NY and Chemical and Pharmaceutical Publ. Corp., Paris.

Cowardin, L., V. Carter, C. Golet, and E.T. LaRoe. 1979. Classification of wetland and deepwater habitats of the United States. Fish and Wildlife Service, U.S. Department of the Interior, Washington, D.C.

Elliot, J.M. 1977. Some methods for the statistical analysis of samples of benthic invertebrates, Second edition. Freshwater Biological Association Scientific Publication No. 25.

Ernst, W.R., P. Jonah, K. Doe, G. Julien, and P. Hennigar. 1991. Toxicity to aquatic organisms of off-target deposition of endosulfan applied by aircraft. Environ. Toxicol. Chem. 10:103-114.

Frank, R., K. Johnson, H.E. Braun, C.G. Halliday, and J. Harvey. 1991. Monitoring air, soil, stream and fish for aerial drift of permethrin. Environmental Monitoring and Assessment 16:137-150.

Grue, C.E., M.W. Tome, T.A. Messmer, D.B. Henry, G.A. Swanson, and L.R. DeWeese. 1989. Agricultural chemicals and prairie pothole wetlands: Meeting the needs of the resource and the farmer - U.S. perspective. Trans. N. Amer. Wildl. Nat. Res. Conf. 54:43-58.

Lackey, R.T. and B.E. May. 1971. Use of sugar flotation and dye to sort benthic samples. Trans. Am. Fish. Soc. 4:794-797.

Shaw, S.P. and C.G. Fredine. 1956. Wetlands of the United States. U.S. Fish Wildl. Serv. Circ. 39. U.S. Department of the Interior, Washington, D.C.

Waters, T.F. 1969. Sub sampler for dividing large samples of stream invertebrate drift. Limnol. and Ocean. 14:813-815.

Table 1. Densities of invertebrates in different treatments before and after application of esfenvalerate to adjacent crop lands in western Minnesota, July, 1990. Data were transformed to $\text{Log}_{10}(X+1)$ and values presented are geometric means. This was a split-plot experiment in which time was a subplot treatment. The only probabilities of a greater value of F less than 0.10 were $p=0.09$ for the (time by treatment) interaction in sweep net samples and $p=0.06$ for (treatment) in other benthic invertebrates. Probabilities given in parentheses are from an analysis of a completely randomized sampling design for invertebrate abundance before application of esfenvalerate, including data from Waterfowl Production Areas.

Collection of samples in relation to application of esfenvalerate	<u>Adjacent to Cropland</u>		Waterfowl	
	Reference	Treatment	Production Area	
Total invertebrates per sweep net sample				
Before	630	200	(320)	($p = .026$)
After	250	250		
Benthic chironomid larvae per m^2				
Before	7,700	3,100	(15,000)	($p = 0.19$)
After	7,700	2,500		
Benthic invertebrates other than chironomids per m^2				
Before	1,600	620	(740)	($p = 0.36$)
After	2,000	500		

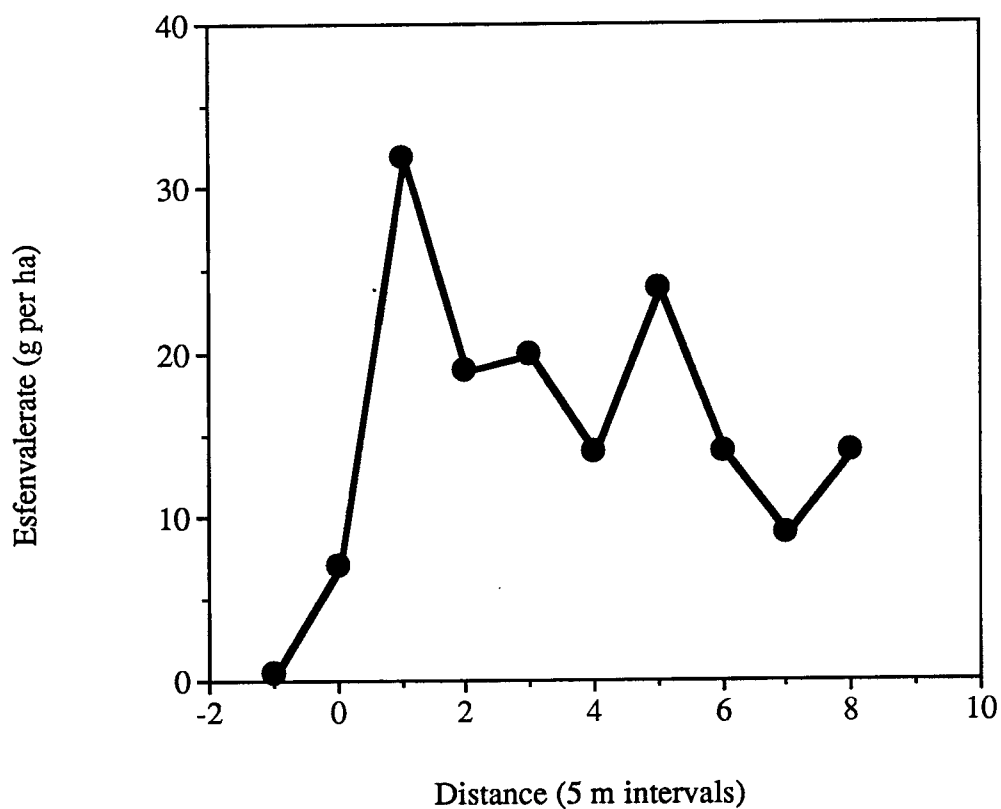


Figure 1. Mean concentrations of esfenvalerate deposited on spray cards located at 5 m intervals along transects established near 5 wetlands adjacent to fields treated with insecticide in 1990. One end of the transect near each wetland was located in the native vegetation adjacent to the wetlands 5 m in from the edge of the cropland and the other end extended 40 m out into the cropland. The transect was perpendicular to the border between the cropland and wetland.

Appendix I. Invertebrate abundance in pre-treatment wetland core samples.

Wetland	Chironomidae	Dytiscidae	Haliplidae	Hydrophilidae	Chrysomelidae	Corixidae	Notonectidae
A1	598	0	6	1	0	0	0
A2	268	2	0	0	4	0	0
A4	172	0	0	1	1	0	0
A5	233	0	6	0	0	0	1
T1	55	0	0	0	1	0	0
T2	83	1	0	0	0	1	1
T3	16	0	0	0	0	0	0
T4	572	1	0	0	0	0	0
T5	50	0	0	0	0	0	1
W1	80	1	0	0	1	0	0
W3	714	0	2	0	0	0	0
W4	195	0	0	0	0	0	0
W5	676	0	1	2	0	0	0

Appendix I cont'd.

Wetland	Anisoptera	Zygoptera	Ephemoptera	Chaoboridae	Ceratopogonidae	Stratiomyidae
A1	0	0	2	0	0	1
A2	1	21	18	0	2	0
A4	0	14	13	0	0	0
A5	0	2	1	1	17	0
T1	0	1	0	0	0	0
T2	3	0	3	0	29	0
T3	0	0	0	0	0	0
T4	0	1	0	0	1	0
T5	0	0	0	0	1	0
W1	0	0	1	0	2	0
W3	0	1	0	2	13	0
W4	0	0	0	7	0	0
W5	0	0	0	0	0	0

Appendix I cont'd.

Wetland	Ephydriidae	Oligochaeta	Hirudinea	Lepidoptera	Canaceidae
A1	0	61	1	0	0
A2	0	12	0	0	0
A4	0	71	0	0	0
A5	0	0	0	0	0
T1	2	4	0	0	0
T2	0	0	0	0	1
T3	0	1	0	1	0
T4	0	1	0	1	0
T5	0	0	0	1	0
W1	1	12	0	0	0
W3	0	33	1	0	0
W4	0	3	0	0	0
W5	0	1	0	0	0

Appendix II. Percent invertebrate abundance in pre-treatment wetland core samples.

Wetland	Chironomidae	Halipidae	Zygoptera	Ephemoptera	Ceratopogonidae	Oligochaeta
A1	89.6	0.89	0	0.29	0	9.1
A2	83	0	6.5	5.6	0.6	3.7
A4	63	0	5	4.8	0	26.2
A5	89	2.3	0.77	0.39	6.6	0
T1	91	0	1.6	0	0	6.7
T2	72	0	0	2.6	25.2	0
T3	95	0	0	0	0	5
T4	99.4	0	0.18	0	0.18	0.18
T5	98	0	0	0	2	0
W1	84	0	0	1	2.1	12.6
W3	93	0.26	0.13	0	1.7	4.2
W4	98.5	0	0	0	0	1.5
W5	99.7	0.15	0	0	0	0.15

Appendix III. Percent invertebrate abundance in post-treatment wetland core samples.

Wetland	Chironomidae	Halipilidae	Zygoptera	Ephemoptera	Ceratopogonidae	Oligochaeta
A1	95.8	0	0	0	0	4.2
A2	75	3.75	2.5	0	0	18.75
A4	65	6	4	3	2	19.8
A5	92	0	0	0	2.5	5
T1	80	0	3.3	0	3.3	13.3
T2	87	5	0	5	2.5	0
T3	100	0	0	0	0	0
T4	99	0	1	0	0	0
T5	50	16.6	16.6	0	0	16.6